

Localization of gravitational field energy and a procedure proposed for its experimental verification

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Abstract

Introduction of Vaidya metrics into the Expansive Nondecelerative Universe model allows to localize the energy of gravitational field. On the assumption that there is an interaction of long-range gravitational and electromagnetic fields, the localization might be verified experimentally. In this contribution some details on such an experiment are given.

Introduction

The law of universal gravitation was formulated by I. Newton in 1666. 250 years later A. Einstein showed that his equations describing gravitation had wavelike solutions, similar to the wavelike solutions of Maxwell's equations. Just as a time-varying charge distribution excites electromagnetic waves, so a time-varying mass distribution will excite gravitational waves. Yet, scientific community is still waiting for a direct detection of gravitational waves. Moreover, contrary to the other fundamental forces, there is neither comprehensive theory allowing to quantify, localize and measure the gravitational field nor any experimental evidence on the above mentioned characteristics of the gravitational field. One of the main sources of this marking time lies in the Schwarzschild metrics that has been generally accepted in elaborated models of the Universe and gravitation. Usage of this metrics in models of the Universe has led to a conclusion on the impossibility to localize the gravitational field outside a body. The model of Expansive Nondecelerative Universe (ENU) is virtually one of the first, if not the only, which is fully consistent with the laws of nature (the requirement which must be satisfied by any acceptable model), its predictions and conclusions are in accordance with experimental observations and, thanks to the introduction of Vaidya metrics into its mathematical tools, it provides, contrary to other models, a mode of localization and quantification of the gravitational energy.

Within the research focused on unification of all four fundamental forces several important theoretical results have emerged, no experimental data on a mutual interaction and/or interference of any of them with gravitation are, however, known. One of the principal obstacles lies in substantially different range of the forces. From this viewpoint only the gravitational and electromagnetic forces are similar since the both are far-reaching and their intensity varies inversely with the square of the distance between two bodies (masses or

charges). These similarities have led us to considerations on the theoretical and experimental treatment of possibilities to verify the existence of interference of these forces. In this contribution theoretical background of the verification is given.

Theoretical Background

The density of gravitational field in the domain of weak fields is described by Tolman's equation

$$\epsilon_g = -\frac{R \cdot c^4}{8\pi \cdot G} \quad (1)$$

where R is the scalar curvature. In Schwarzschild metrics

$$R = 0 \quad (2)$$

that is interpreted as an impossibility to localize the gravitational energy outside a body. In the Expansive Nondecelerative Universe model (further ENU) [1 - 3] the gauge factor a is expressed as

$$a = c \cdot t_c = \frac{2G \cdot M_U}{c^2} \quad (3)$$

where M_U is the mass of the Universe and t_c is the cosmologic time and at present

$$a \cong 10^{26} m \quad (4)$$

$$t_c \cong 4.5 \times 10^{17} s \quad (5)$$

It follows from eq. (3) that in ENU the matter creation occurs. The total energy of the Universe must, however, be exactly zero [4]. It is achieved by a simultaneous gravitational field creation, the energy of which is $E < 0$. Such a Universe may, therefore, permanently expands with the velocity of light c and the fundamental conservation laws are still observed.

Due to the matter creation, Schwarzschild metrics may not be used and should be replaced by another kind of metrics allowing to take the matter creation phenomenon into account. Such a property exhibits Vaidya metrics [5]. Since it holds in ENU [2, 3]

$$\frac{dm}{dt} = \frac{m_o}{t_c} \quad (6)$$

where m_o is the rest mass of a body, using Vaidya metrics and eq. (6), relation (7) defining the scalar curvature is obtained

$$R = \frac{3R_{g(m)}}{a \cdot r^2} \quad (7)$$

in which $R_{g(m)}$ is the gravitational radius of a body with the mass m . It follows [1] from (1) and (7) that

$$\epsilon_g = -\frac{3mc^2}{4\pi a r^2} \quad (8)$$

where ϵ_g is the density of gravitational field energy emitted by a body with the mass m in the distance r . Relation (8) can be rewritten as

$$\epsilon_g = \frac{3E_g}{4\pi \cdot \lambda^3} \quad (9)$$

where E_g is the energy of a gravitational quantum and λ is its Compton wavelength

$$\lambda = \frac{h \cdot c}{2\pi \cdot E_g} \quad (10)$$

Substituting in (9) for (10) and comparing the result with (8), the expression for an energy quantum E_g is obtained [1]:

$$|E_g| = \left(\frac{m \cdot h^3 \cdot c^5}{8\pi^3 a \cdot r^2} \right)^{1/4} \quad (11)$$

where E_g is the quantum of gravitational energy created by a body with the mass m in the distance r . Relation (11) is in conformity with the limiting values: the maximum energy is represented by the Planck energy, the minimum energy equals the energy of a photon with the wavelength identical to the Universe dimension ($a = \lambda$).

Gravitational output P_g , defined as the amount of gravitational energy emitted by a body with the mass m in a time unit is given as (12)

$$P_g = \frac{d}{dt} \int \epsilon_g dV = -\frac{m \cdot c^3}{a} = -\frac{m \cdot c^2}{t_c} \quad (12)$$

Experimental verification

Both the gravitational and electromagnetic forces are of long-range nature and their intensity decreases with the square of distance. Supposing an interaction of the fields and stemming from the localization of the gravitational field energy, an experiment may be proposed in which the interference of the fields might lead to a change in the mass of the tested body acting as an emitter. To perform the experiment, the following requirements must be satisfied.

(a) A body - emitter with the mass m_e should emit photons with the energy E_{ph} identical to the energy of Earth gravitational field quanta $E_{g, Ea}$. Taking the known mass m_{Ea} of the Earth (5.97×10^{24} kg), its mean radius r_{Ea} (6.37×10^6 m) and the values of the other members in (11) into account, it follows

$$E_{g, Ea} = \left(\frac{m_{Ea} \cdot h^3 \cdot c^5}{8\pi^3 a \cdot r_{Ea}^2} \right)^{1/4} \cong 1.49 eV \quad (13)$$

that corresponds to the wavelength

$$\lambda \cong 834 nm \quad (14)$$

(this is a wavelength from the near-infrared region used in telecommunications). One of the conditions, therefore, is that the emitter should emit photons of the wavelength 834 nm. Such photons might interfere with quanta of the gravitational field of the Earth.

(b) Relation (12) states that the electromagnetic output of the emitter P_e is to be

$$P_e = \frac{m_e \cdot c^2}{t_c} \quad (15)$$

Relations (14) and (15) represent the conditions of equality of the electromagnetic and gravitational output of the emitter. If, in principle, may exist an interference of the electromagnetic and gravitational fields of the emitter and the Earth, such an interference might happen and be observed.

(c) Since electronic transitions associated to excited state formation and radiation deactivation are accompanied by vibrational-rotational (i.e. thermal) relaxation, and the radiation output of the emitter is usually influenced by its temperature, within the proposed experiment it will be necessary to maintain constant temperature.

(d) After the required energy and output of the emitter P_e are reached, the emitter should be weighted at different directions of the emission. The

interference should manifest itself as a change in the emitter weight that, given a balance with a sufficient sensitivity is used, should be registered.

(e) There can be a necessity to adjust the wavelength and energy output values (the accuracy of their values depends on the accuracy of all parameters in used relations).

(f) Providing the radiation is not monochromatic (a common case) the output of that with 834 nm (or that of adjusted wavelength) must correspond to that required by relation (15).

(g) The mass m_e of the emitter is its own mass not including peripheral parts.

Conclusions

1. The proposed experimental verification of interference of the gravitational and electromagnetic fields may lead to successful results providing three conditions are fulfilled: the ENU model describes the Universe in a correct way; there is in principle a possibility of the interference; conditions stated in paragraphs (a) to (g) are met.

2. Any changes in the mass of an emitter caused by the discussed interference would be of far-reaching scientific and technological importance.

3. The present contribution deals only with the theoretical aspects of the experiment, its realization requires solutions of many practical tasks.

References

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